TEACHER EVENT CHECKLIST
SPACE FARMING EXPEDITION (Plant Growth in Space)

Date Completed	PRE EVENT REQUIREMENTS
	1. Print out a copy of this entire file (color copy preferred). Please note: this document is 15 pages long.
	2. Sign Agreement to Participate on page 2 and E-mail it to Distance Learning Outpost within 3 business days of confirmation.
	3. Have students take Pre-Event Quiz on page 5.
	4. Complete all pre-event activities on page 4 with the students.
	5. Teacher to E-mail a minimum of 5 student questions to our office no later than 3 business days prior to your event.
	6. Review NASA Event Guidelines on page 12 with students.
	DAY OF EVENT ACTIVITIES
	1. The students will be asked to share their results from their pre-work activities with the NASA DLO presenter.
	POST EVENT REQUIREMENTS
	1. Have students take Post-Event Quiz on page 5 for evaluation and assessment.
	2. Teacher(s) and students to fill out event feedback on page 13.
	2. Distance Learning Outpost will respond to any follow-up questions.
	3. At teacher's discretion, students can complete extended activities on page 13.

Teacher Agreement To Participate
NASA's Distance Learning Outpost

I have reviewed the Space Farming Learning Module and agree to complete all of the required activities with my students, both prior to, and following, the video teleconferencing event.

Teacher(s) ______________________________

School/Institution ______________________________

Event # ______________________________

Date of Event ______________________________

Fax this form to the Distance Learning Outpost Office at (281) 483-3789

or

E-mail to dlo1@jsc.nasa.gov within 3 business days of confirmation.

Instructional Goal

Upon completion of this learning module, students will be able to explain why space farming is crucial to long-term expeditions in space and how it can be achieved.

Learning Objectives

1. Students will be able to list several requirements for plants to grow.

2. Students will be able to explain how the requirements for plant growth can be met off of Earth.

3. Students will be able to discuss why space farming is necessary for long-term space missions.

National Education Standards

Science Standards (NSTA)

Abilities to Do Scientific Inquiry
Understanding about scientific Inquiry

Life Science
Structure and Function in Living Systems

Mathematics Standards

Understand numbers
Ways of representing numbers, relationships among numbers, and number systems

Texas Essential Knowledge and Skills (TEKS)

Science

5.2 C,D
6.2 C,D
6.13 B
7.2 C, D
7.9 A, B
7.12 C
8.2 C, D
8.11A

Grade Level:

Grades 5-8

Estimated Time Requirements:

1. Preparation Time
   a. Time necessary to download & print the lesson from the computer
   b. Time necessary to become familiar with the lesson
2. Execution Time by Activity
   a. Activity Set #1 30 minutes
   b. Activity Set #2 (choose one)
      i. Activity A 50 minutes
      ii. Activity B 80 minutes
   c. Activity Set #3 25 minutes
   d. Video Teleconference 50 minutes

STUDENTS WILL BE ASKED TO SHARE THEIR WORKSHEET AND PROPOSAL DURING THE VIDEO TELECONFERENCE WITH NASA.

INSTRUCTIONAL STRATEGY

Pre-Event Classroom Component

Activity Set #1

1. Students take the Pre-Event Quiz on page 5 to test their knowledge prior to lessons about Space Farming. Students keep these quizzes on file to compare to their Post-Event Quiz for evaluation and assessment.

2. Students should become familiar with the terminology on page 7 that will be used in the activities and during the event with NASA. It is up to the teacher's discretion on how and when to introduce the terms.

Activity Set #2

Please select at one, ideally both, of the activities below (A-B) to complete with your class.

1. Activity A on page 8

   In this activity, students are introduced to the environment in space. First, the students will brainstorm using the knowledge they already have to decide what the requirements are for plants to grow healthy and strong. Second, they will think about how plants naturally receive those requirements on Earth and how the plants might receive the same requirements in space. **Students will be asked to discuss their worksheet results during the video teleconference**.

2. Activity B on page 11

   In this activity, students get the opportunity to research space farming and why it is important to our future. They will work in teams of 6 to create a proposal responding to the Congressional Finance Subcommittee statement that no additional plant research is necessary on the ISS. Each team will then give a 2-3 minute presentation of their proposal in front of the class.
   If students complete this activity, they will be asked to discuss their proposal and presentation during the video teleconference.

Activity Set #3

1. Student Questions
   - Develop at least 5 questions from the class on Space Farming
   - These questions should go beyond the basic information within the program
   - These questions should attempt to demonstrate "higher cognitive involvement" by the students
   - E-mail your questions at least 3 business days prior to your event with NASA
   - E-mail address is: DLO1@jsc.nasa.gov

2. Prepare students for their participation in a live, interactive video teleconference with NASA's Distance Learning Outpost using the guide on page 12.

Pre/Post Quiz
Space Farming Expedition

1. What do plants require to grow on Earth?

2. Which of the requirements you decided on in #1 are also *naturally* provided off of Earth?

3. For each of the requirements you came up with in #1 that does *not* naturally occur off of Earth, explain how we might supply it.

4. Why is it important that we know how to grow healthy plants off of Earth?

Pre/Post Quiz
Space Farming Expedition

TEACHER ANSWER KEY – Please don't share with the students. Answers should be similar to:

1. What do plants require to grow on Earth?

   Plants need the correct temperature, carbon dioxide, light, nutrients, and water.

2. Which of the requirements you decided on in #1 are also *naturally* provided off of Earth?

   None are.

3. For each of the requirements you came up with for plant growth that does *not* naturally occur off of Earth, explain how we might supply it.

   Accept any answer that makes sense. There is not one answer to this question because there are many ways to supply each requirement; it is just that some are more efficient than others.

4. Why is it important that we know how to grow healthy plants off of Earth?

   Currently we cannot do long-term space missions because we are dependent on Earth to supply us with our supplies. If we are ever to send humans to Mars or to the moon for more than a few days, the crew needs to be independent of Earth and grow their own plants. Plants not only provide food and oxygen, they also recycle wastewater and create an aesthetically pleasing and emotionally comforting atmosphere for the astronauts.

Space Farming Terminology

The following is a list of words and definitions that your students need to be familiar with because the words are used throughout the activities and video teleconference. They will be asked to explain the meaning of these terms **in their own words** during the teleconference.

Hydroponics — The growing of plants in nutrient solutions with or without an inert medium to provide mechanical support

Photosynthesis — The process by which a plant uses the energy from the light of the sun to produce its own food using chlorophyll

water + carbon dioxide in the presence of light = sugar + oxygen

Gravitropism — The response of plants to the pull of gravity, including the tendency for plant roots to grow downward in the direction of gravity and plant shoots to grow upward against gravity

Hydrotropism — The growth of an organism or a part, such as a root, in response to the presence of water

Phototropism — Growth or movement toward or away from a light source

Macronutrients — Nutrients required in the greatest amount (e.g., carbohydrates, protein, fats.)

Micronutrients — Substances needed only in small amounts for normal function (e.g., vitamins or minerals)

Microgravity — Freefall causes reduced gravity, NOT zero gravity. There is still gravity it is just very weak.

The thirteen essential minerals for plants include nitrogen (N), potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), sulphur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), boron (B), and chlorine (Cl).

Background Articles to Help You Become Familiar with Space Farming

1. Off-Planet Plants — http://nasaexplores.com/search_nav_5_8.php?id=03-014&gl=58
2. Plants In Space — http://nasaexplores.com/search_nav_5_8.php?id=01-048&gl=58

Activity A
Space Farming Expedition

Brainstorming the Differences Between Growing Plants on Earth and in Space

<u>Materials</u>

- *Earth vs. Space* worksheet (1 per student) on page 9
- *Earth vs. Space* transparency (1) – teacher made
- *Earth vs. Space* answer key on page 10
- Pen or pencil
- Paper

<u>Background</u>

In order for health plants to grow on Earth, several requirements must be met. These same requirements must also be met if we want to grow the same healthy plants off of Earth. By establishing what the requirements are, we can then figure out how to supply these needs to the plants when they are not grown on Earth.

<u>Procedure</u>

To complete this activity, you will need the *Earth vs. Space* worksheet and transparency. This activity allows the students to brainstorm new ideas based on their current knowledge.

1. As a class, discuss the environment in space. See what the students already know before telling them what it is like (cold in the dark, extremely hot in sunlight, vacuum, microgravity). As the students give responses, write them down on the overhead/board. (Allow up to 15 minutes)

2. Read the directions on the *Earth vs. Space* worksheet.

3. Working individually, have the students complete the worksheet according to its directions. (Allow up to 15 minutes)

4. Working in pairs, have the students compare their answers and add anything that they don't already have on their worksheet. (Allow up to 5 minutes)

5. As a class, complete the *Earth vs. Space* transparency. To do this, simply have one person (teacher or student) write down the class' results. Be sure to get answers from all groups and that the class is in agreement with the answers. (Allow up to 15 minutes)

6. End class by asking the students, "Why it is important for us to know how to grow plants in space?" This is not meant to be answered at this time; rather, it is to get the students thinking about the question for tomorrow's lesson.

<u>Student Presentation</u>
Students will be asked to discuss their worksheet results during the video teleconference.

Earth vs. Space Worksheet

Name: _________________________________ Class: ________ Date: ________

Directions: Using your knowledge of plants, consider what is needed for plants to grow. As you think of each necessity, write it under “Plant Requirement”. Only place one requirement in each square. When you cannot come up with any more requirements, continue on by filling in the remaining columns.

Plant Requirement	How is it met naturally on Earth?	Met naturally in space? (Y/N)	If no, how can humans fulfill the requirement?

Earth vs. Space

ANSWER KEY

Name: ________________________________ Class: ________ Date: ________

Directions: Using your knowledge of plants, consider what is needed for plants to grow. As you think of each necessity, write it under "Plant Requirement". Only place one requirement in each square. When you cannot come up with any more requirements, continue on by filling in the remaining columns.

Accept any reasonable responses.

Plant Requirement	How is it met naturally on Earth?	Met naturally in space? (Y/N)	If no, how can humans fulfill the requirement?
Light	Sun	N (long periods of darkness)	Artificial lighting (light bulbs)
Temperature	Sun	N (space is VERY cold)	Heater + heat from light bulbs
Carbon Dioxide	Atmosphere	N (space is a vacuum)	Humans exhale CO_2
Water	Oceans, lakes, rivers, rain	N (yet to find liquid water)	Recycle human wastewater
Nutrients	Soil	N (yet to find a soil with the needed nutrients)	Fertilizer
Others?			

Activity B
Space Farming Expedition

International Space Station Plant Research WebQuest

Materials

- Internet Access
- Printer
- Scissors
- Butcher Paper
- Pens
- Pen or pencil
- Paper

Background

One of the major purposes of the International Space Station (ISS) is to provide a microgravity environment to perform research experiments. So far there has been a lot of focus on plant growth on the ISS and the results have been quite valuable. Although there are many people in support of the plant growth studies, some people are not sure that we should continue to pour money into it.

In this activity, students get the opportunity to research space farming and why it is important to our future. They will work in teams of 6 to create a proposal responding to the Congressional Finance Subcommittee statement that no additional plant research is necessary on the ISS. Each team will then give a 2-3 minute presentation of their proposal in front of the class.

Procedure

Reminder: This activity will take two class periods (one to research and prepare presentation + one for presentations and evaluation). Depending on your available time, this could also be made into a three class period activity.

1. Become familiar with the *ISS Plant Research WebQuest* so you are able to answer any questions the students may have.

   ISS Plant Research WebQuest http://voyager.cet.edu/iss/activities/webquest/questmain.html

2. All of the information you need is included in the WebQuest. Note: There are links at the bottom of the site that will direct you to helpful teacher resources and student resources.

Student Presentation
Students will be asked to discuss their proposal and presentation during the video teleconference.

NASA Event Guidelines

Review the following points with your students prior to the video teleconference event:

1. A video teleconference is a two-way event. Students and NASA presenters can see and hear one another.
2. Students are representing their school; they should be on their best behavior.
3. Students should be prepared to give brief presentations, ask questions and respond to the NASA presenters.
4. A Teacher(s) or other site facilitator should moderate students' questions and answers.
5. Students should speak into the microphone in a loud, clear voice.

Get Ready, Be Ready, and have fun with your Distance Learning Event with NASA!

Post Event Teacher – Student Evaluation

1. **We need your help and support**! Choose the appropriate Form below. It usually takes teachers and students **less than 10 minutes** to complete. We welcome any input that you have at the following sites:

    1. Teacher Feedback Form:
       https://ehb2.gsfc.nasa.gov/edcats/centers/distance_learning.html

    2. Student K-4 Feedback Form:
       TBD

    3. Student 5-8 Feedback Form:
       TBD

    4. Student 9-12 Feedback Form:
       TBD

    5. Technical Contact Feedback Form:
       https://ehb2.gsfc.nasa.gov/edcats/centers/jsc_dlo_tech_contact.html

    6. Parent/Chaperone Feedback Form:
       https://ehb2.gsfc.nasa.gov/edcats/centers/distance_learning_parent.html

2. Students and Teachers are **welcome to e-mail the Distance Learning Outpost** with any follow-up questions from the event at: mailto:DLO1@jsc.nasa.gov

3. **Please send** us any photos, video, web page link, newspapers articles, etc. of your event. We will be glad to post them on our web page!

Extended Activities for Space Farming

1. Perform further research on the Internet at:

   http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Space.Food.and.Nutrition/Space.Food.and.Nutrition.pdf

   or

   http://www.nasa.gov/

2. Activity C on page 14

   In this activity, students are allowed to be creative. Using their knowledge, teams of 2-3 students design a plant container to be used in space. The final design must meet all of the constraints listed and explained in the *Plant Container Restraint* handout.

Activity C
Space Farming Expedition

Designing a Plant Container for Use in Space

Materials
- *Plant Container Constraints* handout
- Pen or pencil
- Paper

Background

Clearly space farming is crucial for long-term space missions. However, it is not so clear how to go about growing the plants. Besides the requirements that the plants have in order to grow strong and healthy, scientists must also keep in mind the constraints regarding where the plants will be grown.

Inside the Space Shuttle, in addition to serious concern for safety, everything must be adapted to microgravity. The purpose of the *Plant Container Constraints* handout is to help students transfer their thinking from Earth-normal growing conditions for plants, to what is normal in space flight, or space-normal growing conditions for plants. Remember that the Shuttle and International Space Station (ISS) environments are microgravity environments; the Moon has 1/6 gravity and Mars has 1/3 gravity of Earth. Growing conditions for habitats on the Moon and Mars would be somewhat different. For this activity, we will focus on Shuttle and ISS "space-normal" conditions.

Procedure

By the end of this activity students will have designed, as a drawing on paper, a plant container for use in space on a shuttle.

1. As a class, discuss the term "**microgravity**". (Allow up to 15 minutes)
   a. What is gravity? *Force that pulls objects toward Earth's surface.*
   b. What is microgravity? *Freefall…reduced gravity.*
   c. If our classroom was suddenly in a microgravity environment, describe what would change. *Anything not secured to the floor, walls, or ceiling would "float". Without gravity there is no true up or down…the ceiling or walls can be the "floor" in a microgravity environment.*
   d. How does microgravity make a difference on plant growth? *Plants do not naturally know which direction to grow. This is why **hydrotropism** and **phototropism** is often used in space.*

2. Introduce today's activity. (Students will design, on paper, a plant container for use in space aboard the Space Shuttle or ISS.)

3. Hand out and go over the *Plant Container Constraints* handout. (Allow up to 10 minutes)

4. Allow students to team up in groups no larger than three to design, on paper, (not create) their plant containers. They are also required to write a few paragraphs explaining their design, one final copy per team. (Allow the remainder of class to work on it)

Plant Container Constraints Handout

While designing your plant container, you must keep in mind the constraints put on your final product. There is limited room, weight, time, power, water, and air available. So make sure you follow the guidelines otherwise your container will not make it aboard the Space Shuttle.

SIZE: All items must be contained within a 1-cubic meter box (1m x 1m x 1m)

WEIGHT: Less than 50-pounds (It costs approximately $10,000 to launch 1-lb into orbit)

TIME: Limited to 10 minutes per day of astronaut time to check on your plant box (needs to have easy access)

POWER: 120 volts

WATER: Must be self contained, within your weight and size limitations; very impressive if you can come up with a system to utilize wastewater from the crew.

AIR: Drawn from the crew cabin, assume a temperature of 68 degrees Fahrenheit. If you want it warmer, you'll need to provide a heat source (don't forget the heat from your lights.)

Reminder about microgravity:

- Water: In space, free water forms a sphere. Astronauts cannot just pour water onto your plant because the water will not fall down because there is very little gravity present.
- Soil: All items must be contained in space, meaning that there cannot be any bits of soil or dust floating in the cabin.
- Convection currents: There are no convection currents in this environment. This means that if there is no fan, or some other means to blow air around, hot light bulbs tend to explode, and plants tend to wilt in their own waste gases.
- Day/Night: In a typical orbit, sunrise comes every 90 minutes. Use sunlight in your purpose if you wish, but remember that most of the crew's work is not done in direct sunlight, and a 90-minute day/night cycle can cause problems with growth and flowering.

Pollination: Though we have flown bees and other insects in space, for this project, none will be allowed in the plant hardware.